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IMPROVEMENT OF PIGMENT AND LIPID STABILITY IN BEEF WITH VITAMIN E TREATMENTS

MITSURU MITSUMOTO[1], R. G. CASSENS, D. M. SCHAEFER and R. N. ARNOLD

Department of Meat and Animal Science, University of Wisconsin-Madison, Madison, Wisconsin, United States
[1] Department of Animal Production, Chugoku National Agricultural Experiment Station, Kawai-cho, Oda-shi, Shimane-ken, 694, Japan

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INTRODUCTION

Metmyoglobin formation and lipid oxidation are the most important problems in maintaining a stable display of retail beef. Many studies have provided information that the use of vitamin E, a biological antioxidant, prevents pigment and lipid oxidation in vitro and in vivo. The post-mortem addition of vitamin E increased the pigment or lipid stability in pork (Miles *et al.*, 1986; Whang *et al.*, 1986) and ground beef (Benedict *et al.*, 1975). Dietary supplementation of vitamin E was shown to decrease pigment or lipid oxidation in meat from poultry (Webb *et al.*, 1972; Marusich *et al.*, 1975), pigs (Hvidsten and Astrup, 1963; Tsai *et al.*, 1978) and cattle (Faustman *et al.*, 1989a,b).

The purpose of this work was to study the effects of postmortem vitamin E addition and dietary vitamin E supplementation on the pigment and lipid stability in beef.

MATERIALS AND METHODS

Post-mortem vitamin E (Experiment 1; Mitsumoto et al., 1991a)

Longissimus lumborum (LL) muscles from six crossbred beef steers were used. The left strip loin from each steer was removed at 24 hours after slaughter, vacuum-packaged and stored for an additional six days at 4°C. The caudal 15cm of each LL muscle was ground three times through a 0.45cm plate of a laboratory meat grinder at 4°C.

The d-α-tocopherol was added at a concentration of 6mg/kg tissue into ground meat. Vitamin E solution was freshly prepared by dissolving d-α-tocopherol in white mineral oil (0.6mg/ml). Chlortetracycline (CTC) was blended into ground meat at 30mg/kg tissue for prevention of microbial growth and to isolate the effect of vitamin E addition. CTC was dissolved in distilled water (3mg/ml).

Two 200g aliquots of ground meat were allotted to the following treatments: 2ml CTC solution + 2ml white mineral oil (control) and 2ml CTC solution + 2ml vitamin E solution (post-mortem vitamin E addition). Immediately after these solutions were added, each ground meat sample was thoroughly hand-mixed. Samples of 20g of the treated meat were then shaped into miniature beef patties using the bottom half of a tissue culture dish (15x60mm). These patties were placed into 100ml disposable weigh boats, over-wrapped with PVC film and displayed under cool white fluorescent lights (2475 lux) at 4°C for seven days.

Dietary vitamin E (Experiment 2; Mitsumoto et al., 1991b)

The LL muscles from eight crossbred beef steers and ten Holstein steers were used. Four crossbred beef and five Holstein steers were fed no supplemental vitamin E, and the other four beef and five Holstein steers were supplemented with 1200 I.U. α-tocopheryl acetate per animal daily for 67 and 38 days respectively. Cattle were fed a 90% high-moisture corn-10% corn silage diet formulated to contain 0.1ppm selenium.

The left strip loin from each steer was removed 24 hours after slaughter, vacuum-packaged and stored for an additional six days at 4°C. The LL muscles were sliced into 1cm thick steaks and 50mm diameter pieces were cut from these sliced steaks with a template cutter. All samples were individually placed on styrofoam, over-wrapped with PVC film and continuously displayed under cool white fluorescent lights at 4°C for 16 days.

Vitamin E analysis

The α-tocopherol concentrations in muscles were measured by the method of Cort *et al.* (1983).

Metmyoglobin analysis

Surface metmyoglobin percentage was determined at 1, 3, 5 and 7 days (Experiment 1) and 1, 4, 7, 10, 13 and 16 days (Experiment 2) by reflectance spectrophotometry (Krzywicki, 1979).

Lipid oxidation analysis

2-Thiobarbituric acid (TBA) values were measured by the method of Witte *et al.* (1970) in samples displayed for 1, 3, 5 and 7 days (Experiment 1) and 1, 4, 7, 10, 13 and 16 days (Experiment 2). Trichloroacetic acid solution (20% w/v) was used for the extraction blending. TBA values were expressed as mg malonaldehyde /kg meat.

Statistical analyses

Data were analyzed by the General Linear Models procedure of SAS (1985). Pairwise comparisons of means were analyzed by Scheffe's test (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

Experiment 1

Vitamin E addition reduced surface metmyoglobin percentages (22.5% to 42.2%; Figure 1) and TBA values (0.47 to 2.16; Figure 2) in ground beef compared to the control (metmyoglobin percentages; 24.2% to 57.6% in Figure 1, and TBA values; 1.18 to 4.34 in Figure 2) during seven days of display. Previous researchers observed that the addition of vitamin E inhibited lipid oxidation to some extent in pork (Miles *et al.*, 1986; Whang *et al.*, 1986) and in ground beef (Benedict *et al.*, 1975). These reports indicated that vitamin E at the concentrations of 50-200mg/kg meat was effective in reducing lipid oxidation. We found that even a very small concentration of 6mg vitamin E /kg meat was effective in retarding pigment and lipid oxidation.

Experiment 2

The average of α-tocopherol concentration of LL muscles was increased ($P<0.01$) by vitamin E supplementation in both the crossbred beef steers (control, 2.2; supplemented, 6.0mg/kg) and Holstein steers (control, 2.2; supplemented, 3.5mg/kg; SE=0.2).

Dietary vitamin E supplementation to cattle retarded metmyoglobin formation (20.6% to 31.7%; Figure 3) and greatly suppressed lipid oxidation (0.05 to 0.33; Figure 4) in beef cuts compared to the control (metmyoglobin percentages; 20.2% to 60.5% in Figure 3 and TBA values; 0.13 to 3.41 in Figure 4) during 16 days of display. Vitamin E supplemented steers had lower metmyoglobin percentages (Figure 3) from day 7 and lower TBA values (Figure 4) from day 1 than the control steers. These results showed that dietary vitamin E supplementation retarded metmyoglobin formation and greatly suppressed lipid oxidation in beef cuts. Faustman *et al.* (1989a, b) also reported that vitamin E supplementation (370 I.U./animal/day) of Holstein steers effectively stabilized meat colour and lipid of the gluteus medius.

Monahan *et al.* (1990) confirmed α-tocopherol deposition in the cellular membranes of pigs fed vitamin E-supplemented diets. Therefore, we suggest that dietary vitamin E was absorbed by steers and incorporated into cellular membranes. In this location vitamin E prevented pigment and lipid oxidation directly by reacting with free radicals and also indirectly maintained metmyoglobin reducing activity; hence, the stabilities of beef colour and lipid were improved.

Relationship between α-tocopherol concentration and, metmyoglobin percentage and TBA value at day 16 is presented in Figure 5. Supplemented steers (3.2-6.4mg α-tocopherol/kg) showed lower metmyoglobin percentages and TBA values than control steers (1.7-2.5mg α-tocopherol/kg), and α-tocopherol concentrations over 3.5mg/kg meat appeared to retard metmyoglobin formation and lipid oxidation. The results indicated that dietary vitamin E supplementation should be maintained at a level to obtain 3.5mg α-tocopherol per kg meat.

CONCLUSION

Post-mortem vitamin E addition was effective in retarding pigment and lipid oxidation in ground beef compared to the control. Dietary vitamin E supplementation retarded pigment oxidation and highly suppressed lipid oxidation in beef cuts compared to the control. We found that post-mortem vitamin E addition and especially dietary vitamin E supplementation improved pigment and lipid stability in beef.

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